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Index Terms:
asynchronous transfer mode packet switching transport protocols Internet telecommunication control MPLS functionality ATM switching system IP over ATM technology private networks public backbone networks Internet service providers telecommunication operators packet forwarding engine MPLS controller HANbit ACE 64 system multiprotocol label switching

STRUCTURES OF AN ATM SWITCHING SYSTEM WITH MPLS FUNCTIONALITY

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Abstract

MultiProtocol Label Switching (MPLS) is a new IP over ATM technology that can be deployed in private networks as well as in public backbone networks operated by Internet service providers or telecommunication operators. From the viewpoint of telecommunication, we propose several structures of an ATM switching system having MPLS functionality that swaps a label at packet forwarding engine and controls a label switched path at MPLS controller. The proposed structures are discussed, and compared with each other according to their features. We also introduce the new ATM switching system named HANbit ACE 64 system that supports the MPLS functionality.

1. Introduction

As various Internet services are explosively extending and high bandwidth traffic such as multimedia application is also growing, current Internet users require much more capability on Internet. With some solution to a flood of Internet traffic, there are several efforts to adapt ATM (Asynchronous Transfer Mode) technology to Internet for building high-speed Internet backbone. These efforts are categorized into two kinds of IP over ATM technologies, overlay model and integrated model. In overlay model approaches, there are IPOA (IP Over ATM)[1], LANE (LAN Emulation)[2], and MPOA (MultiProtocol Over ATM)[3]. For integrated model approaches, we have IP switching[4], Tag switching[5], and recently MPLS (MultiProtocol Label Switching)[6].

MPLS, as one of the integrated model approaches, is an emerging IETF (Internet Engineering Task Force) standard architecture and is based on the Tag switching of Cisco. The primary concept of MPLS is that it ties power of layer 2 up to routing connectivity of layer 3. As a result, MPLS has benefits that reduce costs and a number of connectivity compared with other IP on ATM technologies. Hence, it can be deployed in private networks as well as in public backbone networks operated by Internet service providers or telecommunication operators.

To add the MPLS features, conventional router vendors have developed some software performing MPLS functionality for their existing products that can already support IP routing and IP packet forwarding for Internet service. Also, telecommunication companies are developing or have developed ATM switching systems supporting MPLS service. Ericsson presented AXD 301 switching system including specific subsystem for MPLS functionality, and other switching systems including IP packet forwarding capability in addition to the specific MPLS subsystem[7,8].

In this paper, we describe MPLS overview in chapter 2. Several structures of an ATM switching system with MPLS functionality are presented in chapter 3. In chapter 4, we introduce characteristic features of the HANbit ACE 64 system that can be used to support Internet Service. Finally, conclusions are added.

2. MPLS Overview

MPLS, a technology for backbone networks, can be used for Internet protocol as well as for other network layer protocols. These backbone networks may have several types of transmission and switching capabilities such as ATM, Frame Relay, Ethernet, SONET, and SDH.

In the current Internet, the basic function of routers is to forward packets from source to destination. To do this, each router gets routing information and status of networks by routing protocols such as RIP (Routing Information Protocol)[9], OSPF (Open Shortest Path First)[10], and BGP (Boarder Gateway Protocol)[11]. The router constructs RIB (Routing Information Base) and FIB (Forwarding Information Base) with the routing information. When an IP packet gets in, the router looks up the FIB and forwards it to an outgoing network interface connected to the networks. MPLS combines the conventional Internet functions, i.e., forwarding and routing capabilities, with transmission and switching capabilities such as ATM.

MPLS takes an approach introducing a connection-oriented mechanism in the connectionless IP networks. In an MPLS network, a LSP (Label Switched Path) is established for each route or path through the network. The edge routers analyze the header of an IP packet to decide which LSP is to be used, and add a corresponding identifier, in the form of label, to the packet as it is forwarded to the next hop. Once this is done, all the subsequent nodes may simply forward the packet along the LSP identified by the label at the front of the packet. The connection-oriented principles introduced with MPLS not

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only allow the improvement of the forwarding capacity of conventional routers, but also enable ATM and FR (Frame Relay) switches to be deployed as forwarding devices.

MPLS network is shown in figure 1. The MPLS network is configured with LER (Label Edge Router) connected to non-MPLS network and LSR (Label Switched Router) that performs label swapping.

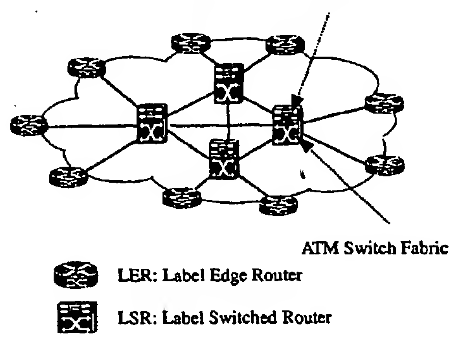

Figure 1. MPLS Network.

3. Structures of an ATM Switching System with MPLS Functionality

We propose several structures of an ATM switching system with MPLS functionality that swaps a label at packet forwarding engine and controls a LSP at MPLS controller. Largely, we consider two parts, IP packet forwarding engine and MPLS controller, in order to construct ATM-MPLS system. Firstly, we discuss the structure of IP packet forwarding engine that is mainly used in LER. The forwarding engine can be either integrated into existing interface modules or located alone independently from other modules. Next, for the structure of MPLS controller, we consider three types of the MPLS controllers. These are an MPLS controller integrated within an existing call control processor of an ATM switching system, a separated MPLS controller implemented in an ATM switching system, and an external MPLS controller implemented as an independent server of an ATM switching system. We compare the proposed MPLS structures in terms of processor, operating system, call control, switch management, redundancy, and flexibility. From the basis of such knowledge, we will choose an appropriate structure for implementing the forwarding engine and the MPLS controller.

3.1 Packet forwarding Engine in an ATM-LER system

In ATM-LER, IP packets are segmented into labeled ATM cells and then forwarded to LSR, or the labeled ATM cells are reassembled into the IP packets and then forwarded to the non-MPLS network. Therefore, we need the operation of labeling encapsulation or decapsulation, and forwarding function in an ATM-LER. There are two kinds of FE (Forwarding Engine). The first one is the FE, like as FE(1) in figure 2, included in IM (Interface Module) or line card without any extra device. In that case, the load of IP traffic processing should be light because of the distributed configuration. The other one is the FE implemented as an extra device like as FE(2) in figure 2. In the configuration of FE(2) of the ATM-LER, all IP traffic passing through IM's is centralized at the FE(2). Hence, the FE must have powerful capacity to process such a heavy traffic load. If ATM network is already configured and the change of existing IM's for FE deployment is not desirable, then we will install additional FE to an existing ATM switching system. Configurations of FE in an ATM switching system is shown in figure 2.

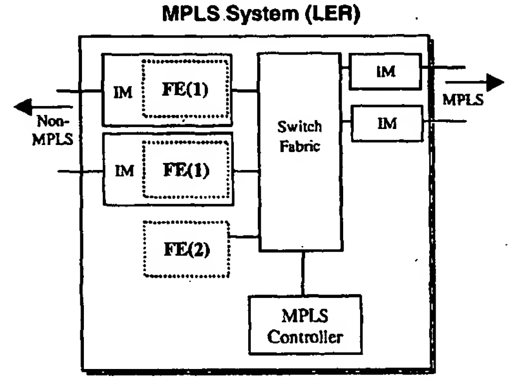

Figure 2. Configurations of FE in an ATM switching system

3.2 MPLS controller integrated within an existing call control processor

In this section, we consider the structure of an integrated MPLS controller placed in an existing call control processor of an ATM switching system. The processor should have processing functions of LDP (Label Distribution Protocol)[12], routing protocol, and IP packet forwarding in addition to the call and connection control functions. The structure of an integrated MPLS controller is shown in figure 3.

This structure does not need any additional processor and operating system for the MPLS controller because we use the existing processor called CCCP (Call and Connection Control Processor), and its own operating system of the CCCP. The CCCP is usually implemented with duplicated or redundancy scheme for high reliability and availability[13]. This structure has some intrinsic advantages since it can ensure economical efficiency and

support high reliability by utilizing the existing reliable control processor. On the other hand, operating system of the CCCP must have supplementary Internet networking functions such as IP, TCP, socket interface, and IP packet forwarding driver. Also, MPLS control software should be added and integrated into the existing call control software. Due to the software bulkiness and/or the inflexibility of operating system, the performance of this system may be tremendously degraded.

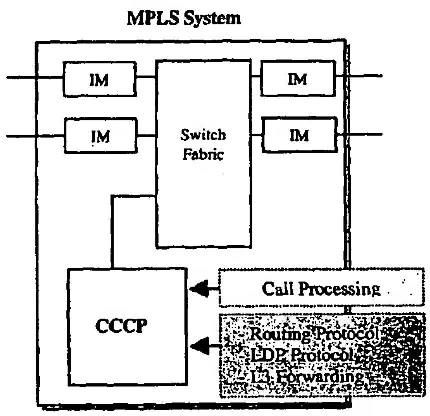

Figure 3. Structure of an integrated MPLS controller

3.3 Separated MPLS controller in an ATM switching system

The MPLS controller can be placed in an ATM switching system as a separated processor, which has processing functions of LDP, routing protocol, and IP packet forwarding. Figure 4 shows the structure of a separated MPLS controller in an ATM switching system.

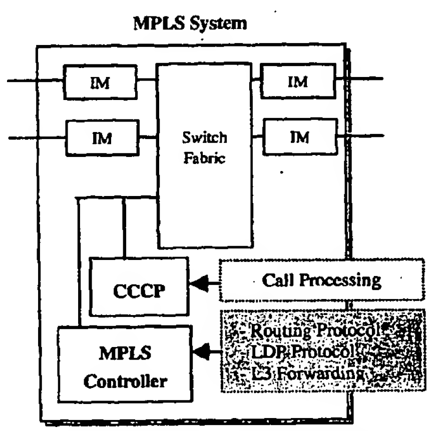

Figure 4. Structure of a separated MPLS controller

This structure does not depend on an existing processor environment because it has a new independent MPLS control processor. The MPLS control processor can be equipped with a real time operating system having Internet networking functions. This ATM-MPLS structure achieves conventional call processing at the existing call control processor and MPLS functions at the MPLS controller all at once. Hence, CCCP and MPLS controller give free play to their performance. However, it requires inter-processor communication mechanism for the interface between the MPLS controller and the ATM resource control function in CCCP.

3.4 External MPLS controller

Finally, the MPLS controller can be placed outside of an ATM switching system as an external system. It is connected to the ATM switching system by ATM physical link, and has processing functions of routing protocol, LDP protocol, and IP packet forwarding. Figure 5 shows the structure of an external MPLS controller.

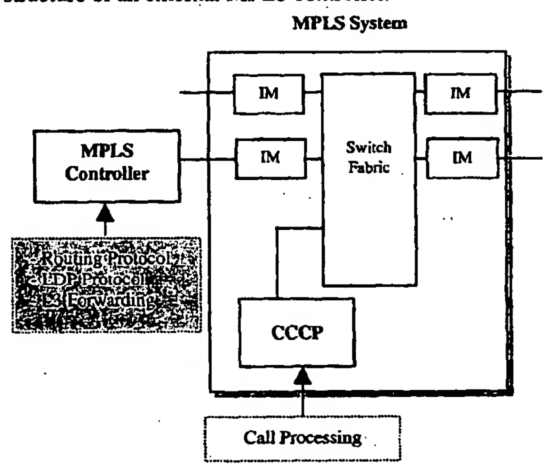

Figure 5. Structure of an External MPLS controller

This structure does not depend on an existing processor environment any more, and enables the MPLS controller freely implemented. It has high flexibility with commercial system. On the other hand, there are some considerations that it has to interface between the MPLS controller and an ATM resource control function in CCCP to integrate management and administration features of existing functions and the MPLS controller.

3.5 Comparisons

In this section, we summarize and compare features of the proposed MPLS controller structures. Table 1 shows characteristic features of the proposed MPLS structures.

Items	Integrated Structure	Separated Structure	External Structure
Processor	existing	needed	needed
Operating System	existing, but needs to be changed	needed	needed
Call Control	existing	not needed	not needed
Switch Control and Management	existing	required (depends on the existing system)	required (GSMP[14] like)
Management & Administration	integrated	integrated or separated	separated
Redundancy	existing	may be needed	-
Flexibility	no	no, but partially yes	yes

Table 1. Comparisons of proposed MPLS structures

Additional processor and operating system are needed in the separated and external structures, but not in the integrated one. In the integrated structure, call control software resides in the same processor along with the MPLS control software. In the separated and external structures, we need inter-processor communication mechanism to interface the MPLS controller with the switching management function in CCCP. System management and administration for ATM and MPLS are integrated in the integrated structure, but in the separated and external structures, they are separated into two independent ones for ATM and MPLS, respectively.

4. HANbit ACE 64 System with MPLS functionality

In this chapter, we introduce the HANbit ACE 64 system[15,16,17], which is a new ATM switching system developed by ETRI and can provide Internet service. The system is based on a scalable architecture that can change smoothly the system capacity from low to large scale and can guarantee user's QoS efficiently without system bottleneck. In addition, the system can be used in several positions in a network by providing various ATM and non-ATM interfaces and their related functions.

A structure of MPLS-based HANbit ACE switching system is proposed as shown in figure 6. From the several MPLS structures described in the previous chapter, we chose the structure of the centralized forwarding engine and the MPLS controller located in an ATM switching system as a separated processor.

The HANbit ACE 64 switching system consists of several sub-systems with ALS-ST (Access Line Sub-system-Subscriber and Trunk) and ALS-IP (Access Line Sub-system-Internet Protocol). ALS-ST sub-system accommodates STM-1, DS3, DS-E physical link for UNI and STM-1, STM-4 physical link for NNI. The sub-system has SIM, TIM for interfacing physical line and ASNM for cell switching, and CCCP (Call and Connection Control Processor) for call control. The sub-system supports ITU-T UNI and NNI as well as ATM forum UNI and PNNI. ALS-IP sub-system provides pure ATM network capability as well as processing of IP packet forwarding. Therefore, the sub-system behaves as a SIN (Ships In the Night) mode. Like the ALS-ST, the ALS-IP accommodates STM-1, DS3, DS-E physical link for UNI and STM-1, STM-4 physical link for NNI. The sub-system has SIM, TIM for interfacing physical lines, and ASNM for cell switching, and CCCP for call control. Additionally, for Internet, LIM (Label Interface Module) and IPCP (Internet Protocol Control Processor) are newly added. The existing CCCP handles ATM call control and the added IPCP deals with Internet routing protocol, label distribution, label mapping, label splicing, and IP routing for MPLS. Interface between an ATM resource control function and the MPLS controller is done by GSMP protocol. LIM processes layer 3 fast lookup, high-speed packet forwarding, IP encapsulation/decapsulation of AAL5 type, conversion of AAL5 packet from/to ATM cell by referring to LIB, and label swapping.

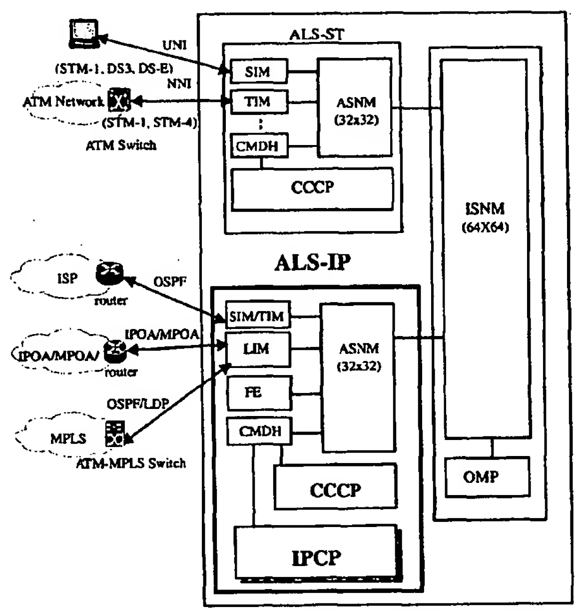

Figure 6. A Structure of HANbit ACE 64 Switching System.

For IP packet forwarding, first of all, MPLS functions in the ALS-IP sub-system perform followings. Routing protocol function collects routing information to make RIB

and FIB in MPLS network. Label distribution control function establishes LSP by referring to the FIB, that is, produces LIB. LIM is informed of the LIB for label swapping. Diagram of IP packet forwarding is shown in figure 7.

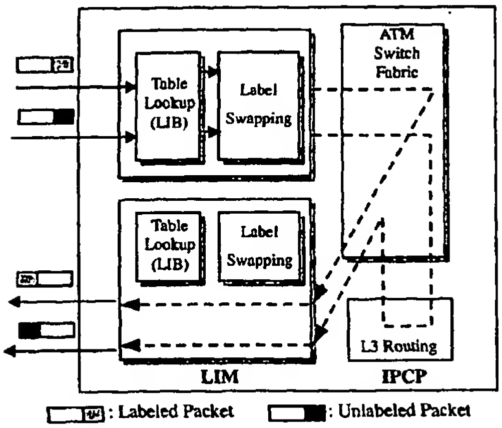

Figure 7. Diagram of IP Packet Forwarding.

5. Conclusion

The primary benefits of MPLS are that it ties power of layer 2 up to routing connectivity of layer 3. MPLS also reduces costs and a number of connectivity compared with other IP on ATM technologies.

We proposed several structures of an ATM switching system with MPLS functionality that swaps a label at packet forwarding engine and controls a LSP at MPLS controller. Forwarding engine can be either integrated into existing interface modules or located alone independently from other modules. For the MPLS controller, we considered three types of MPLS controller structure: an integrated MPLS controller placed within an existing call control processing processor, a separated MPLS controller in an ATM switching system, and an external MPLS controller as an independent server of an ATM switching system.

The features of proposed ATM-MPLS structures were compared in terms of processor, operating system, Internet protocol, routing protocol, LDP, call control, switch management, redundancy, and flexibility. Finally, we presented the new ATM switching system named HANbit ACE 64 system with MPLS functionality that can be used to support Internet service.

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